UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Tool Wear Characterization of Carbide Cutting Tool Insert in a Single Point Turning Operation of AISI D2 Steel

Report submitted to Universiti Teknikal Malaysia Melaka in partial fulfillment for Bachelor of Manufacturing Engineering (Manufacturing Process)

By

Mohammad Syafiq bin Halim

B 050410038

Faculty of Manufacturing Engineering

Universiti Teknikal Malaysia Melaka

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Dekan,
Fakulti Kejuruteraan Pembuatan

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Process). The members of the supervisory committee are as follow:

<u>Prof. Dr. Mohd. Razali bin Muhamad</u>
(PSM Supervisor)

……………………………………………

ABSTRACT

This study presents tool wear characterization of carbide cutting tool inserts in a single point turning operation of AISI D2 steel. An experiment was conducted in a 20 set of experiment matrix of cutting speed, depth of cut and feed rate and performed on a CNC lathe without coolant. Surface roughness was measured by Mitutoyo profilometer (SJ-301) and flank wear was measured by Axioskop 40. The data was compiled into Design Expert 7 software for analysis. From the result, depth of cut was found to be the main factor to have significant result on surface roughness followed by cutting speed and feed rate. No interaction between the factors was found to give significant effect to surface roughness. The most significant factor for the flank wear is the feed rate while the other two factors did not affected the flank wear. Interaction between depth of cut and feed rate was found to be the factors affected the flank wear. At the end of this study, optimization was made to produce minimum surface roughness and to produce minimum flank wear by suggesting the most suitable sets of parameter settings. Suggestion for both output response was also obtained from the optimization.

ABSTRAK

Kajian ini mendedahkan tentang sifat-sifat perkakas pemotongan sisipan karbaid melalui proses pemotongan satu titik putaran ke atas keluli AISI D2. Satu set eksperimen dengan 20 set nilai laju pemotongan, kedalaman potongan dan kadar potongan dijalankan menggunakan mesin larik CNC dalam keadaan kering tanpa menggunakan cecair pemotong. Kekasaran permukaan diukur mengguakan Mitutoyo profilometer (SJ-301) dan kehausan mata alat pemotongan diukur menggunakan Axioskop 40 dan data-data ini kemudian diisi ke dalam perisian Design Expert 7 untuk dianalisa. Daripada keputusan yang diperolehi, kedalaman pemotongan didapati menjadi faktor penting kepada penghasilan kekasaran permukaan diikuti oleh laju pemotongan dan juga kadar potongan. Tiada interaksi atau saling berpengaruh anatara factor didapati memberi kesan kepada kekasaran permukaan. Kadar potongan adalah faktor yang menjadi pengaruh kepada kehuasan mata alat bukan dua lagi faktor yang terlibat. Interaksi antara kedalaman potongan dan kadar potongan juga menjadi faktor yang mempengaruhi kehausan mata alat.. Di akhir kajian, cadangan untuk setting parameter yang terbaik diberi bagi meminimumkan kekasaran permukaan dan juga meminimumkan kehausan mata alat. Cadangan bagi setting parameter terbaik untuk mendapatkan gabungan peminimuman kekasaran permukaan dan kehausan mata alat juga dibuat.

DEDICATION

For my Parents and Yaya.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

AISI	-	American Iron and Steel Institute
ANOVA	-	Analysis of Variance
BS	-	British Standards
C	-	Carbon
CCD	-	Central Composite Design
Cr	-	Chromium
df	-	Degree of Freedom
DOE	-	Design of Experiment
Fe	-	Iron
HSS	-	High Speed Steel
ISO	-	International Organization for Standardization
Mn	-	Manganese
Mo	-	Molybdenum
NIST	-	National Institute of Standards and Technology
RSM	-	Response Surface Methodology
TiC	-	Titanium Carbide
V	-	Vanadium
W	-	Tungsten

CHAPTER 1

INTRODUCTION

1.1 Background of project

Cutting tool commonly used in metalworking for roughing, drilling, semi finishing and finishing applications and they are also used in making metal objects and metal parts. There are many types of cutting tool that come in hundred of shapes, sizes and uses. Some of the most commonly used cutting tools are angle cutters, end mills, grinding wheels and turning tools.

Wear phenomena has become a nightmare in machining industry because it is absolutely affecting the quality of the product and also the tool life. There are two main types of wear in a cutting tool, flank wear and crater wear. Cutting tool plays an important role in producing good quality of products. Careful selection of cutting tool for machining process for its specific applications is imperetive; to minimize the tool failure during machining process. So, the purpose of this study is to characterize the tool wear of carbide cutting tool insert in single point turning operation of AISI D2 steel.

According to Kalpakjian and Schmid (2001), cutting fluid account up to 15 percent of a shop's production costs. Cutting fluid especially that containing oil has become a huge liability. Because many high speed machining operations create air-borne mists, the amount of cutting fluid mists allow into the air has to be limited. Other than that, the cost of maintenance, record keeping and compliance with current and proposed regulations is rapidly raising the price of cutting fluid hence many machine shops considering eliminating the costs by using dry cutting. Dry cutting is a machining process that uses no coolant during cutting process. Insert tools will perform better when the cutting temperature become higher because there is no coolant during cutting operation. Dry cutting process is able to cut the machining cost and it is also environmental friendly.

1.2 Problem statement

Tool wear will surely happen during machining process. Wear will affect the tool life and the products quality. Improvement needs to be done to increase the tool life. Tool wear characteristic and the effect have to be studied to improve both tool life and product quality. Basically, process parameter related with tool wear characteristic where different parameter will result in different degree of tool wear. From this, optimum parameter can be obtained that will produce minimum tool wear. This situation will produce better tool life performance thus producing good quality products efficiently.

1.3 Objectives

The main objectives of this research are:

1. To study influence of machining parameters such as cutting speed, feed rate and depth of cut to the tool wear of carbide insert.

2. To study the influence of machining parameters such as cutting speed, feed rate and depth of cut to the surface roughness of D2 steel.

3. To define the optimum machining parameter setting (cutting speed, feed rate and depth of cut) to minimize tool wear and surface roughness using RSM for single point turning carbide cutting tool insert on AISI D2 steel work material.

1.4 Scope

To ensure the objective is obtained, the study will be focused on:

1. Tool wear characterization of carbide cutting tool insert.

2. The tool wear to be analyzed are flank wear and crater wear.

3. The experiment will be done using dry cutting single point turning operation.

4. Machining parameters to be used are feed rate, cutting speed and depth of cut.

5. Work material which is AISI D2 steel.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter covers the published work of researchers in the field of machining and cutting tools. In specific, it covers the study on the interaction between cutting parameters and resultant tool wear and surface roughness. Also included in this chapter are machining processes, cutting tool, tool wear, work material, surface roughness, influence of machining parameters to the tool wear and surface roughness followed by design of experiment.

2.2 Turning Process

Turning process is a basic operation that commonly used in metal cutting industry. The work material is held in the chuck of a lathe and rotated for producing products. The tool is held rigidly in a tool post and moved at a constant rate along the axis of the bar, cutting away a layer of metal to form a cylinder or a surface of more complex profile (Trent, 1977).

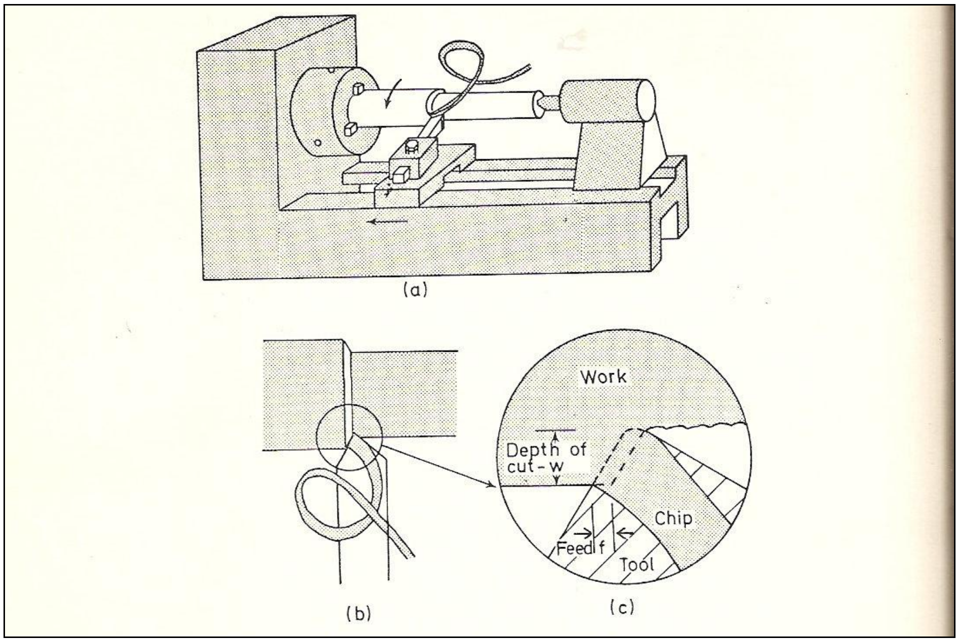

Figure 2.1 Turning process

Figure 2.1 (c) shows the feed rate (f), which is the distance moved by the tool in axial direction at each revolution of the work while Figure 2.1 (b) and (c) shows the depth of cut (w), which is the thickness of metal removed from the bar and measured in a radial direction. The cutting speed (V) means the rate at which the uncut surface of the work passes the cutting edge of the tool. The combination of these three gives the rate of metal removal. Basically, cutting speed and feed rate are adjusted to get optimum cutting conditions while depth of cut is fixed by the initial size of working material and products size.

2.2.1 Machining Parameters

Machining parameters are important factors that affect tool wear and surface roughness in any machining process. Recent studies stated that feed rate is the dominant factor on the surface roughness but it decreased with decreasing cutting speed, feed rate and depth of cut (Y. Sahin and A.R Motorcu, 2007) and another studies by Tugrul Ozel et al

(2007) shows that better tool life is obtained in lowest feed rate and lowest cutting speed combination. This study consists of three machining parameters which are cutting speed, feed rate, and depth of cut.

2.3 Cutting Tool

In general, cutting tool can be defined as part of a machine tool which removes material from the work piece by the used of a cutting medium. In industrial field, many types of cutting tool are used for machining process. Based on Schneider (2001), cutting tool need to have the certain characteristics:

1. Hardness: Hardness and strength of the cutting tool must be maintained at elevated temperatures also called hot hardness.
2. Toughness: Toughness of cutting tool is needed so that tools do not chip or fracture, especially during interrupted cutting operations.
3. Wear Resistance: Wear resistance means the attainment of acceptable tool life before tools need to be replaced.

Insert is one of the cutting tools that are widely used in machining process and it will be used as the cutting tool for this study. Brief explanation about insert will be featured in the next sub-topic.

2.3.1 Cutting Tool Insert

Inserts are individual cutting tool with several cutting points. Inserts are usually clamped on the tool shank with various locking mechanisms (Kalpakjian and Schmid, 2001). Most of high-performance cutting tools use the insert method. Inserts are normally made symmetrically so that when the first cutting edge is dull they can be rotated, presenting a fresh cutting edge. This will effectively increase the life of the tool insert. Figure 2.2 shows some various shapes of insert.

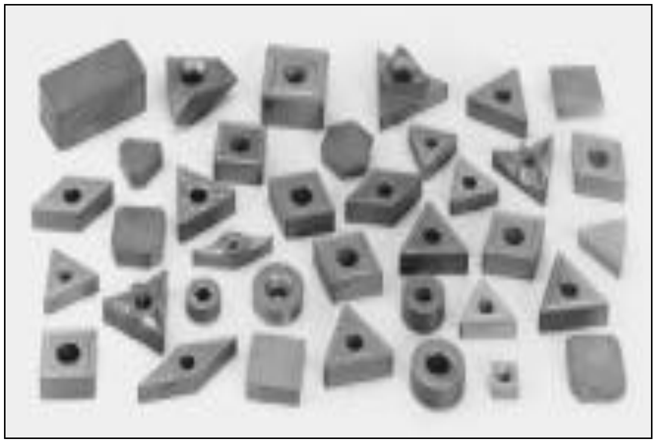

Figure 2.2 Shapes of insert

2.3.2 Cutting Tool Insert Material

A wide range of cutting tool material is available with different properties and performance capabilities. These include carbides, carbon speed steels, cubic boron nitride, diamond and high speed steels. In this study, carbide is chosen as the cutting tool inserts material. Carbide was first developed in the 1930s, able to maintain their hardness over a wide range of temperatures, possesses high elastic modulus and thermal conductivity and low thermal expansion (Kalpakjian and Schmid, 2001). Carbides are among the most important, versatile and cost effective tool and die materials for a wide range of applications. The two basic groups of carbides used for machining operations are tungsten carbide and titanium carbide (TiC). In order to differentiate them from coated tools, plain carbide tools are usually referred to as uncoated carbides.

2.4 Tool Wear

Tool wear normally exist during machining process. In general, tool wear is a gradually process like the wear of the tip of an ordinary pencil. The rate of tool wear depends on tool and work piece materials, tool shape, process parameters and the machine tool itself (Kalpakjian and Schmid, 2001). Basically, tool wear will increase cutting force and cutting temperature and also produce poor surface finish. There are various types of tool wear such as flank wear, crater wear, and build up edge, glazing and edge wear. This study will be focusing on flank wear and crater wear.

2.4.1 Flank Wear

Flank wear occurs on the flank of a cutting tool and caused by friction between the newly machined work piece surface and the contact area on the tool flank. Because of the rigidity of the work piece, the flank wear land must be parallel to the resultant cutting direction and normally the width of the wear land will be taken as the measurement of the amount of wear. This situation is shown in Figure 2.3.